Seasonal and Latitudinal Variations of Surface Fluxes and Meteorological Variables at Arctic Terrestrial Sites

A.A. Grachev[1, 2], T. Uttal[2], P.O.G. Persson[1, 2], E.A. Konopleva-Akish[1, 3], S.M. Crepinsek[1, 2], C.J. Cox[1, 2], C.W. Fairall[4], G. Lesins[4], A.P. Makshtas[5], I.A. Repina[6]

[1] Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder CO, USA; [2] NOAA Earth System Research Laboratory, Boulder, CO, USA;
[3] Science and Technology Corporation, Boulder CO, USA; [4] Dalhousie University, Halifax, Nova Scotia, Canada;
[5] Arctic and Antarctic Research Institute, St. Petersburg, Russia; [6] A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences, Moscow, Russia

44th NOAA ESRL Global Monitoring Annual Conference 2016, May 17-18, 2016, Boulder CO, Poster P-62

Eureka Observatory

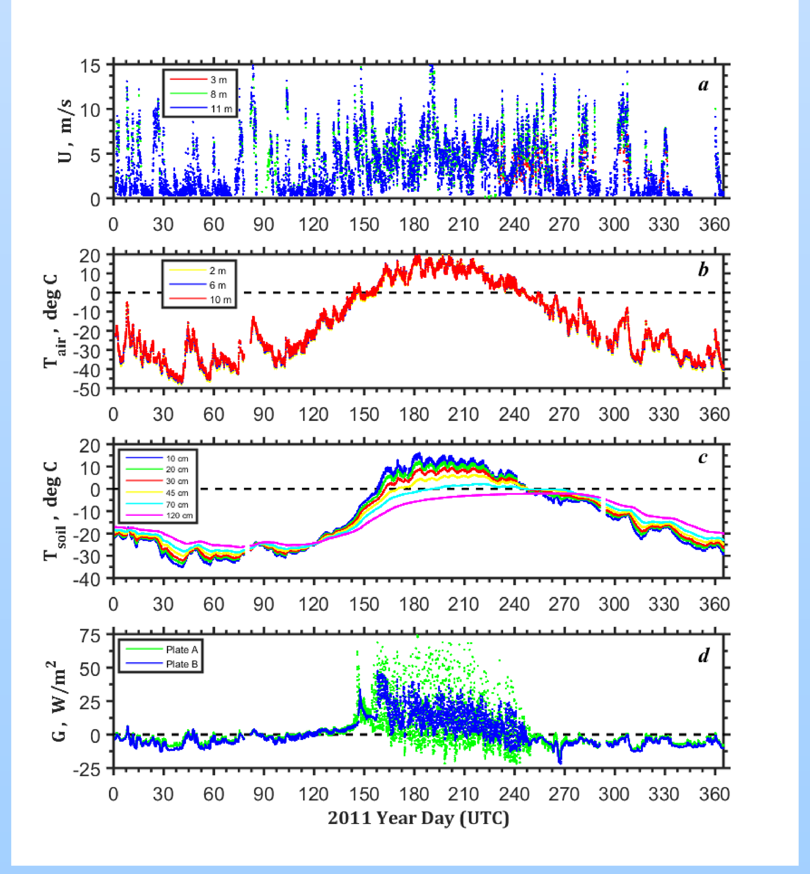
At the Eureka site (80.0 N, 85.9 W) located near the coast of the Arctic Ocean (Canadian territory of Nunavut) many instruments were installed in summer 2007. These include, but are not limited to, a flux tower, a tropospheric ozone lidar and instrumentation that allows Eureka to become a part of the Baseline Surface Radiation Network (BSRN). With IPY funding the level of technical support at the site has been increased to provide an enhanced level of operations and greater operational flexibility, both necessary to pursue measurements of events that are rapidly evolving or have fallen outside normal operational constraints.

This study analyzes and discusses seasonal and latitudinal variations of surface fluxes (turbulent, radiative, and soil ground heat) and other ancillary surface/snow/permafrost data based on in-situ measurements made at two long-term research observatories near the coast of the Arctic Ocean located in Canada and Russia. The hourly averaged data collected at Eureka (Canadian territory of Nunavut) and Tiksi (East Siberia) located at two quite different latitudes (80.0 N and 71.6 N respectively) are analyzed in details to describe the seasons in the Arctic. The primary driver of latitudinal and seasonal variations in temperature and other parameters is the seasonally varying pattern of incident sunlight. The solar radiation at the 'top' of the atmosphere is a function of latitude (and time of year) and the higher latitudes (e.g., Eureka) generally receive the least cumulative amount of net solar radiation than lower latitudes (e.g., Tiksi) over the entire year. However, because of the combined effects of day length and solar zenith angle, Eureka receives more the incoming solar radiation than Tiksi in the middle of Arctic summer. In other words, annual mean of the incoming solar radiation is larger at Tiksi whereas a daily mean in summer is larger at Eureka. Although Eureka and Tiksi are located at the different continents and at the different latitudes, the annual course of the surface meteorology and the surface fluxes are qualitatively very similar. The air and soil temperatures display the familiar strong seasonal trend with maximum of measured temperatures in midsummer and minimum during winter. According to our data, variation in incoming short-wave solar radiation led the seasonal pattern of the air and soil temperatures, and the turbulent fluxes. A length of the warm season (Arctic summer) is shorter and mid-summer amplitude of the turbulent fluxes near solar noon is generally less in Eureka than in Tiksi. During the dark Polar nights, long-lived stable boundary layers can last several months and air/ground temperatures are strongly controlled by long-wave radiation associated generally with cloud cover. The fact that Eureka receives more the total daily amount of the incoming solar radiation than Tiksi throughout the summer months, leads to some differences in the structure of the atmospheric boundary layer and the uppermost ground layer at the two Arctic stations in summer. This study describes a long-lived (1.5-2 months) convective boundary layer (CBL) observed at Eureka during 2009-2014 summer seasons. Long-lived CBL is associated with almost continuous unstable stratification, upward sensible heat flux, and downward carbon dioxide turbulent flux. However, such long-lived CBL is not observed in Tiksi. It was also found that the active layer (or thaw line) is deeper and the soil temperatures are higher at Eureka than at Tiksi. The work is supported by the NOAA Climate Program Office, the U.S. National Science Foundation (NSF) with award ARC 11-07428, and by the U.S. Civilian Research & Development Foundation (CRDF) with award RUG1-2976-ST-10.

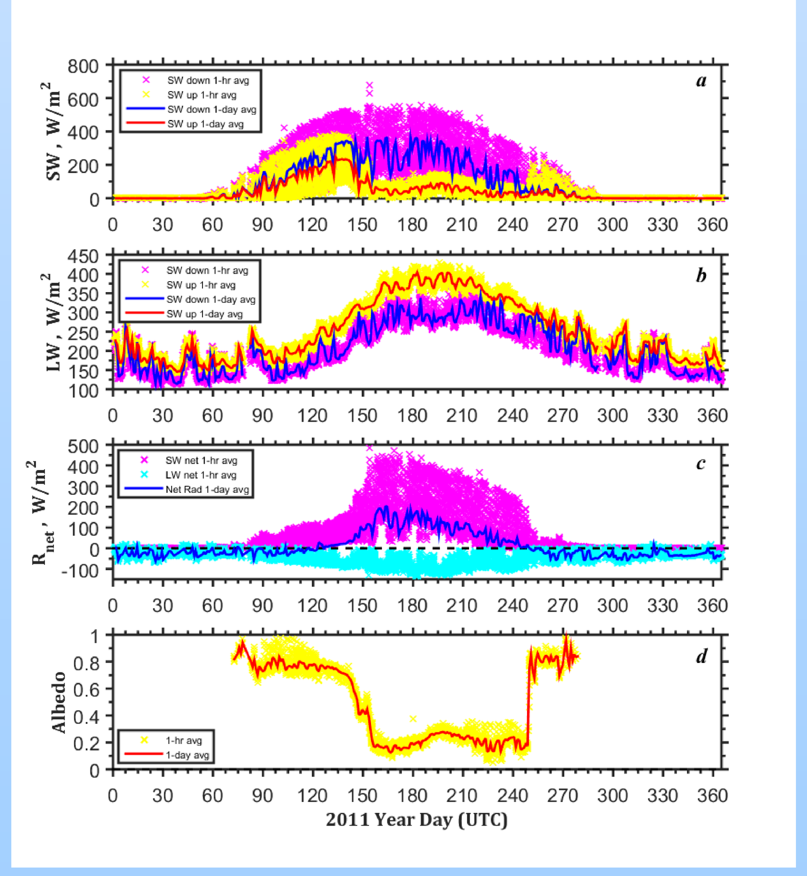
Tiksi Observatory

Russian Tiksi weather station located in East Siberia (71.6 N, 128.9 E) was established at the Polyarka settlement on August 12, 1932 by the chief management of the northern sea route that began collecting geophysical data. The "Polyarka" observatory is located five miles out of town Tiksi. This is now the location for a new Intensive Arctic Observatory site representing a partnership between the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA), and the Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). This facility supports the research needs of the International community, across disciplines including supporting Global Atmosphere Watch measurements as well as other climate observations.

Annual Cycle at Eureka (2011)



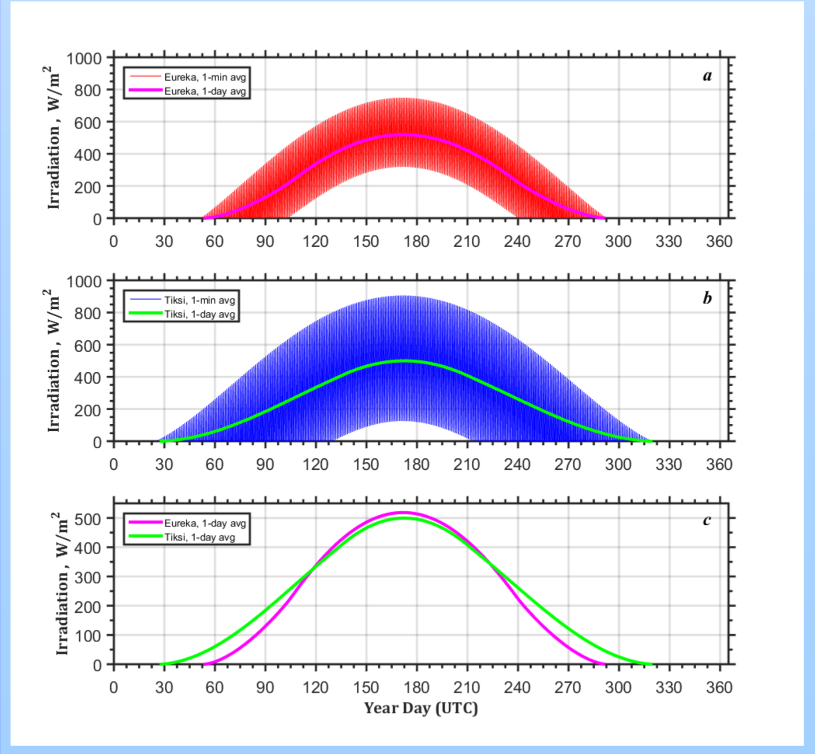
Annual cycle of (a) wind speed at 3, 8 (sonic anemometers), and 11 m (wind vane), (b) air temperature at 2, 6, and 10 m (RTD sensors), (c) soil temperature at 10, 20, 30, 45, 70, and 120 cm, and (d) soil heat flux (plates A and B) observed at Eureka in 2011. The data are based on 1-hour averaging.



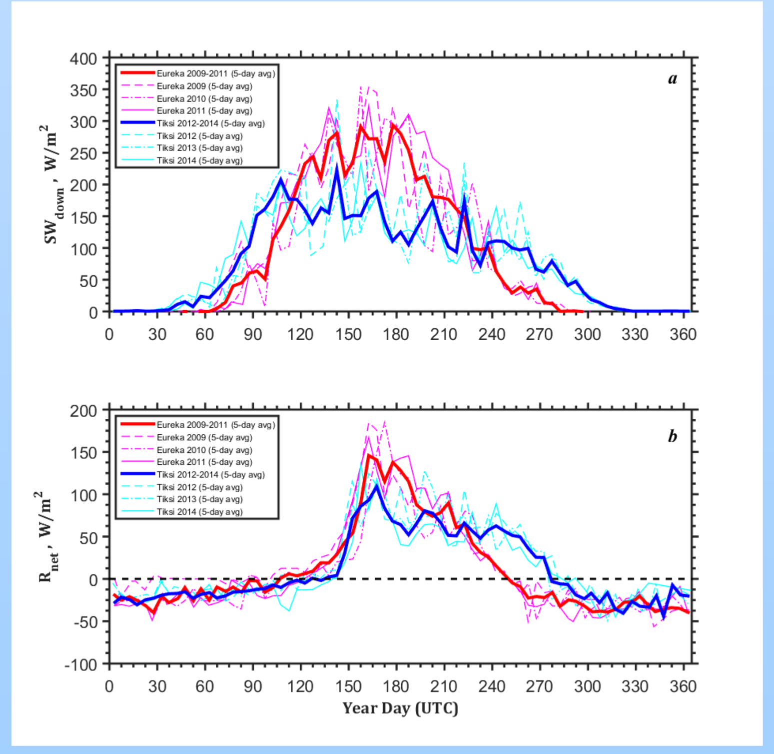
Annual cycle of (a) short-wave (SW) downwelling and upwelling radiation, (b) long-wave (LW) downwelling and upwelling radiation, (c) SW balance, LW balance, and net radiation, and (d) albedo (reflectivity of a surface) observed at Eureka in 2011.

Solar Radiation: Eureka versus Tiksi

Eureka generally receive the least cumulative amount of net solar radiation than Tiksi over the entire year. However, Eureka receives more the incoming solar radiation than Tiksi in the middle of Arctic summer. In other words, annual mean of the incoming solar radiation is larger at Tiksi whereas a daily mean in summer is larger at Eureka.

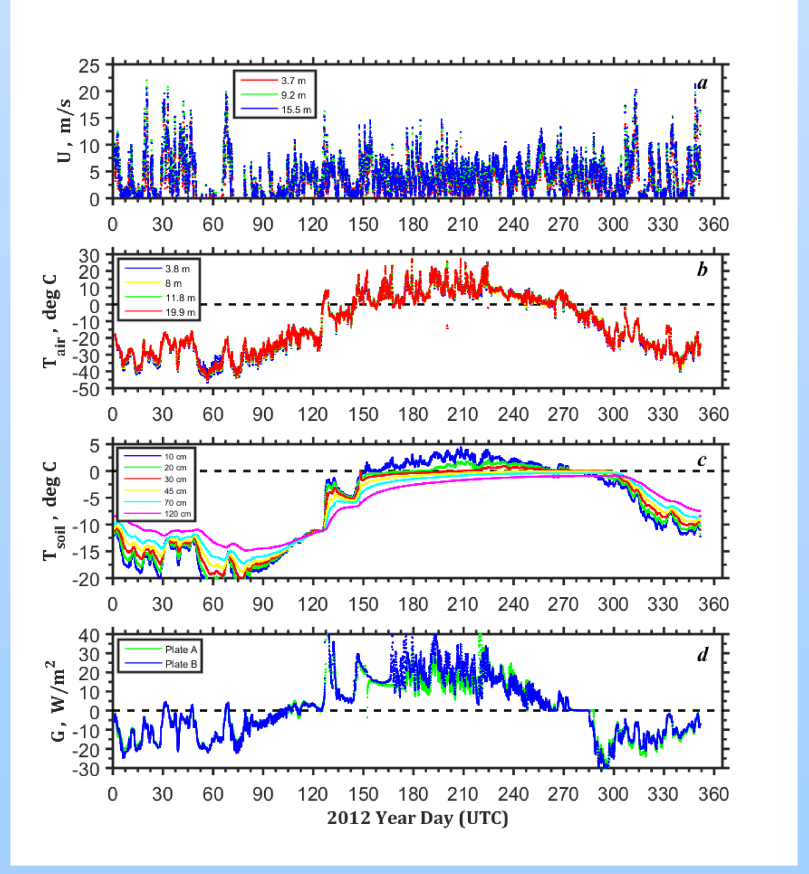


Annual cycle of the solar radiation at the 'top' of the atmosphere (TOA) at (a) Eureka (1-min and 1-day averaged), (b) Tiksi (1-min and 1-day averaged), and (c) Eureka and Tiksi (daily mean TOA flux).

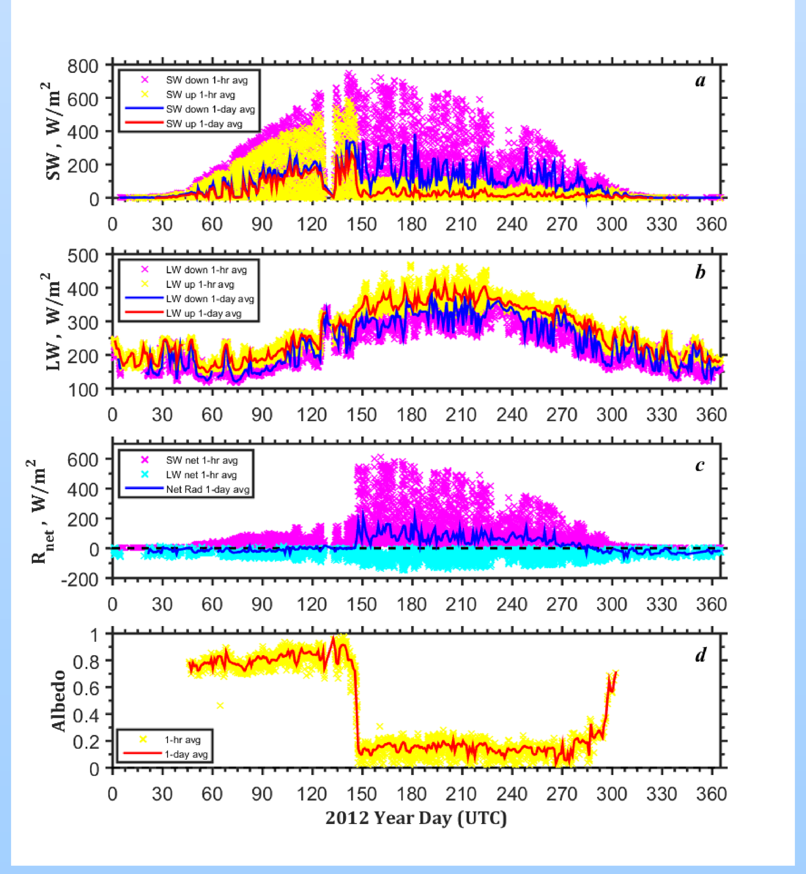


Annual cycle of (a) short-wave (SW) downwelling radiation and (b) net radiation observed at Eureka in 2009-2011 and Tiksi in 2012-2014. The net radiation in the bottom panel is defined as the balance between incoming (positive quantity) and outgoing (negative quantity) SW and LW radiation. The data are based on 5-day averaging of 1-hr radiation measurements.

Annual Cycle at Tiksi (2012)



Annual cycle of (a) wind speed at 3.7, 9.2, 15.5 m (wind vanes), (b) air temperature at 3.8, 8, 11.8, 19.9 m (RTD sensors), (c) soil temperature at 10, 20, 30, 45, 70, and 120 cm, (d) soil heat flux (plates A and B) observed at Tiksi in 2012. The data are based on 1-hour averaging.



Annual cycle of (a) short-wave (SW) downwelling and upwelling radiation, (b) long-wave (LW) downwelling and upwelling radiation, (c) SW balance, LW balance, and net radiation, and (d) albedo (reflectivity of a surface) observed at Tiksi in 2012.